

# Evaluation of the Costs and Benefits of Motorcycle Helmet Laws

ANDREAS MULLER, PhD

**Abstract:** Since 1976, 28 states have repealed or significantly amended their motorcycle helmet laws. The change in legislation was not based on an evaluation of the costs and benefits of such laws. This paper attempts such an assessment by comparing the cost of motorcycle helmets with the medical costs averted due to helmet use using data primarily based on motorcycle crashes in Colorado, Oklahoma, and South Dakota. Nationwide, at least \$61 million could be saved annually if all motorcyclists were to use helmets. Helmet law repeals have been observed to lead to a 40 to 50 per cent point reduction in helmet use. The associ-

ated additional medical care costs substantially exceed cost savings produced by reduced helmet use. It is estimated that helmet law repeals may produce annually between \$16 and 18 million of unnecessary medical care expenditures. Several alternatives to increase motorcycle helmet use are briefly discussed. It is concluded that helmet laws are effective in encouraging helmet use among motorcyclists and will prevent unnecessary medical expenditures as well as unnecessary pain and suffering among injured motorcyclists. (*Am J Public Health* 70:586-592, 1980.)

## Introduction

Motorcycles enjoy increasing popularity in the United States. Between 1967 and 1977 motorcycle registrations increased by 150 per cent from about 2 million vehicles to over 5 million, with most of the increase occurring before 1974. With the increasing number of motorcycles on the highways, the death toll has increased as well. Between 1967 and 1976, the number of motorcycle deaths rose from 1,971 to 3,000, or 5 per cent annually.<sup>1</sup> However, in 1977 the number of motorcycle fatalities alone increased by 770, or 23 per cent, from the previous year.<sup>2</sup>

A U.S. Department of Transportation study relates the rise in motorcycle deaths to the repeal of motorcycle helmet laws in many states. The study notes that, in 11 states which repealed their helmet laws, fatalities increased during the first half of 1977 by one-third when compared with the same period in 1976. In contrast, the number of deaths increased by only 6 per cent in 28 states which retained the law.<sup>3</sup>

Watson's, et al, recent examination of 26 states which repealed or weakened their motorcycle helmet laws further

indicates that the motorcyclist fatality rate increased by 38 per cent over that predicted if laws had remained in effect.<sup>4</sup> This finding is also corroborated by Robertson's study which suggests that the motorcycle fatality rate dropped by 30 per cent after introduction of helmet laws.<sup>5</sup>

In 1976, Congress disallowed the withholding of highway construction funds from states which did not require helmet use for persons over 18 years of age. Since then, 28 states have either repealed or weakened their motorcycle helmet laws.\* Recognizing the waning support for helmet laws, the National Highway Traffic Safety Administration (NHTSA) commissioned several studies to further explore the effectiveness of safety helmets and related regulation.<sup>6-9</sup> No effort has been made, however, to determine the benefit and cost of this legislation to the public. The following paper presents such an analysis which is primarily based on the accident experience of motorcyclists in Colorado, Oklahoma, and South Dakota.

The application of cost-benefit analysis to public health and safety programs encounters formidable problems. The principal benefits of such programs are in terms of lives saved, injuries prevented, or pain and suffering averted,

Address reprint requests to Andreas Muller, PhD, Assistant Professor, Pennsylvania State University, College of Human Development, University Park, PA 16802. This paper, submitted to the *Journal* November 9, 1979, was revised and accepted for publication February 11, 1980.

**Editor's Note:** See also related editorial, p 573, and article, p. 579, this issue.

\*The states are: Alaska, Arizona, Colorado, Connecticut, Delaware, Hawaii, Idaho, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Minnesota, Montana, Nebraska, New Hampshire, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Dakota, Texas, Utah, Washington, and Wisconsin.

while program costs are measured in monetary units. However, cost-benefit analysis requires that cost and benefits be measured in the same units. Several studies conducted by the federal government<sup>10, 11</sup> attempted to overcome this problem by equating the value of lives lost with the value of foregone earnings. But, as Acton points out, this approach is theoretically unfounded and discriminatory.<sup>12</sup> Moreover, many public decision makers and public policy observers find it objectionable to assign dollar figures to human lives.

Due to these difficulties, the present cost-benefit analysis is confined to clearly measurable effects. These are: 1) the cost of motorcycle helmets, and 2) the dollar value of the medical care expenses averted due to the use of the safety device. The limitation of the analysis to these effects will result in an underestimate of the monetary value of the gross benefits and yield a conservative estimate of the net benefits. In addition, an attempt will be made to assess the importance of effects not measured in monetary terms.

### *The Cost and Benefit of Helmet Use*

In this section the costs of helmets will be compared with the cost savings generated by the number of head and facial injuries prevented by helmet use. For ease of calculation, costs and benefits are computed on the basis of 100,000 motorcycles in a given year.

The current retail price for motorcycle helmets ranges between \$11 and \$130 depending upon the type of helmet. The lower price represents the sale price of a standard safety helmet meeting federal standards without a face shield which adds between \$3 and \$10 to the price. A representative of the Safety Helmet Council of America estimates the current average retail price of safety helmets at \$30.\*\*

Since motorcycle helmet laws require that motorcycle drivers and passengers wear helmets, the total expenditure on motorcycle helmets has to be adjusted for the average number of riders per motorcycle. Roadside surveys in South Dakota,<sup>6</sup> Colorado,<sup>7</sup> and Oklahoma<sup>8</sup> observed motorcycle occupancy rates ranging from 1.22 to 1.27 riders per motorcycle. Assuming that the helmet price averages \$30, that the average number of motorcycle riders is 1.25, and the average lifetime of used helmets ranges between 4.1 and 4.9 years,\*\*\* the total annual consumer expenditure is estimated between \$910,194 and \$766,871 per 100,000 motorcycles.

The gross medical care expenditure benefit of helmet use is determined by three factors: 1) the motorcyclist's probability of being involved in crashes; 2) the effectiveness of the safety device; and 3) the amount of medical care expenditures for injuries of different severity class.

The Motorcycle Safety Foundation<sup>13</sup> in connection with the American Motorcycle Association<sup>14</sup> reported 144,115 accidents nationwide in 1976, representing an annual crash in-

volvement rate of 2.9 per cent (144,115/4,979,889 registered motorcycles  $\times$  100). In comparison, the crash involvement rates were somewhat lower in states considered in the analysis. The average crash involvement rate for the period 1973-77 was 2.1 per cent in Colorado,<sup>7</sup> 2.3 per cent in Kansas,<sup>9</sup> and 1.8 per cent in South Dakota.<sup>15</sup> Similarly, the crash involvement rate for motorcycles registered in Oklahoma was 1.9 per cent in 1976 and 2.0 per cent in 1977.<sup>13, 16</sup> To derive a lower bound on the amount of the gross benefit, it will be assumed the crash involvement rate is 2 per cent.

The effectiveness of helmets can be measured by comparing the rate of injury for helmeted and non-helmeted motorcyclists involved in crashes. Specifically, if helmets are effective, the rate and severity of head and facial injury should be lower for helmet users than for non-users. This expectation is supported by several studies which indicate that injured motorcyclists who did not wear helmets had between two and three times higher rates of head and facial injuries than those who wore helmets.<sup>6-9</sup> Also, the average severity of these injuries was found to be significantly higher among injured motorcyclists not wearing helmets.

Table 1 shows the effect of helmet use on the severity of injury as measured by the Overall Abbreviated Injury Scale (OAIS).<sup>17</sup> According to this scale, the crash-involved motorcyclist is assigned a single score based on the clinical judgment of the overall effect of his/her most severe injuries. The data clearly show that non-helmet users are more likely to sustain injuries of higher severity ranking. For instance, non-helmeted motorcyclists are at least two and one-half times as likely to sustain critical and currently untreatable injuries as are helmet users (see OAIS classes 5 and 6).

Adjusting the crash involvement rate by the average occupancy rate of motorcycles (1.25), about 2,500 motorcyclists are expected to have been involved in crashes annually. When this base number is distributed according to OAIS class (see Table 1), the expected number of injured and uninjured riders can be determined for each group of motorcyclists. Helmet effectiveness can then be expressed as the difference between the number of helmet users and non-users for each severity class. The results of these calculations are presented in Table 2.

Faigin's study of the "Societal Costs of Motor Vehicle Accidents," is used as the basis for the valuation of benefits.<sup>18</sup> Among other cost components, the study estimates medical care expenditures on hospitals, physicians, other health care providers, and rehabilitation for each injury severity class. These estimates are presently the best available proxy measure for the cost of head and facial injuries and are presented in the fourth column of Table 2. The multiplication of the cost estimates by those in column 3, results in an estimate of \$1,308,781 for medical care and rehabilitation costs averted in 1975 dollars, or \$2,094,050 in 1979 prices.‡ The

‡For the period 1972-77, the average annual inflation for all health care expenditures varied between 10 and 15 per cent with 12.5 per cent being the mean of the annual averages.<sup>19</sup> It is assumed that an annual inflation rate of 12.5 per cent persists throughout 1975-79, that is, 1979 health care prices exceed 1975 prices by 60 per cent. Thus, 1975 prices are inflated by a factor of 1.6.

\*\*Personal communication May 10, 1979 with Ivan Wagar, President of Safety Helmet Council of America.

\*\*\*See Appendix A for estimation of average number of helmet use years.

**TABLE 1—Distribution of Crash-Involved Motorcyclists by Overall Abbreviated Injury Scale and Helmet Use Status**

OAIS	Helmet Use			
	Yes		No	
		%		%
0. No Injury	605	39.59	347	33.62
1. Minor Injury	388	25.39	198	19.18
2. Moderate Injury	307	20.09	223	21.61
3. Severe Injury (not life threatening)	148	9.68	145	14.05
4. Serious Injury (life threatening, survival probable)	42	2.75	45	4.36
5. Critical Injury (survival uncertain)	15	.98	27	2.62
6. Maximum Injury (currently untreatable)	23	1.51	47	4.55
TOTAL	1,528	99.99	1,032	99.99

SOURCE: Data were aggregated from Dare, et al,<sup>7</sup> (Table 5, p. 13) and from Dorris and Purswell<sup>8</sup> (Table 47, p. 47; Table 23, p. 29).

Note: Result of Kolmogorov-Smirnov test with direction predicted:  $\chi^2 = 9.5 = p < .01$  (2 df).

annual gross benefit exceeds the annual expenditure on helmets by at least \$1,183,856 per 100,000 motorcycles. Extrapolating this figure to all registered motorcycles (approximately 5,150,000), an annual net benefit of \$61 million due to helmet use would be expected nationwide.

### *Costs and Benefits of Helmet Law Enactment and Repeal*

The previous calculations assess the costs and benefits of *motorcycle helmet use*. In contrast, the costs and benefits

of *helmet laws* must be measured by the additional (marginal) costs and benefits arising from law enactment or repeal. The following section will present two methods for estimating these effects. The first method estimates the marginal costs and benefits as a fraction of the *net benefit* due to helmet use (see Table 2).

Large roadside surveys of motorcyclists in seven states have found voluntary helmet use to range between 37 per cent and 64 per cent with a mean helmet use of 51 per cent.<sup>7, 15, 20-24</sup> In contrast, helmet use exceeded 90 per cent in similar surveys which had been conducted the year prior to helmet law repeal (Utah 92 per cent; South Dakota 99.5

**TABLE 2—Expected Number of Crash-Involved Motorcyclists per 100,000 Motorcycles by Injury Severity Class, Helmet Use Status, Related Medical Care & Rehabilitation Costs, and Medical Care Costs Averted**

OAIS	Helmet Use		Difference (3) = (2) - (1)	Medical Care Cost per Person in 1975 (\$) (4) \$	Medical Care Costs Averted (5) = (3) × (4) \$
	Yes (1)	No (2)			
0. No Injury	989.8	840.5	-149.3	0	0
1. Minor Injury	634.8	479.5	-155.3	100	-15,530
2. Moderate Injury	502.3	540.3	38.0	615	23,370
3. Severe Injury	242.0	351.3	109.3	1,620	177,066
4. Serious Injury	68.8	109.0	40.2	7,450	299,490
5. Critical Injury	24.5	65.5	41.0	17,345	711,145
6. Maximum Injury	37.8	113.8	76.0	1,490*	113,240
TOTAL	2,500	2,499.9	—	—1975 (\$)	1,308,781
				1979 (\$)	2,094,050
				Gross Annual Benefit:	\$2,094,050
				Gross Annual Cost: High	\$ 910,194
				Low	\$ 766,871
				Annual Net Benefit: Low	\$1,183,856
				High	\$1,327,179

\*Includes \$925 (discounted at 7%) saved on postponed funeral expenses.

SOURCE: See Table 1

**TABLE 3—Distribution of Crash-Involved Motorcyclists by Overall Abbreviated Injury Scale and Helmet Law Repeal Status**

OAIS	Helmet Law Repeal Status			
	Pre-Repeal Year		Post-Repeal Year	
		%		%
0. No Injury	340	32.47	449	33.04
1. Minor Injury	267	25.50	261	19.21
2. Moderate Injury	203	19.39	309	22.74
3. Severe Injury (not life threatening)	128	12.23	172	12.66
4. Serious Injury (life threatening, survival probable)	70	6.69	93	6.84
5. Critical Injury (survival uncertain)	14	1.34	37	2.72
6. Maximum Injury (currently untreatable)	25	2.39	38	2.80
TOTAL	1,047	100.01	1,359	100.01

SOURCE: Data were aggregated from: Dare et al,<sup>7</sup> (Table 4, p. 12), and from Struckman-Johnson<sup>8</sup> (Table 48, Vol. I, p. 68 and Table 1 in *Appendices*, p. N1).

Note: Result of Kolmogorov-Smirnov test with direction predicted:  $\chi^2 = 9.36 = p < .01$  (2 df).

per cent and Colorado 99.4 per cent). These figures suggest that 40 to 50 per cent of all motorcyclists would not wear helmets voluntarily, but are induced by helmet laws to do so. Assuming that 50 per cent of all motorcyclists wear helmets voluntarily and helmet law enactment will extend helmet use to 95 per cent, helmet law enactment could save annually between \$532,735 and \$597,231 on medical care and rehabilitation expenditures per 100,000 motorcycles. Conversely, the repeal of the helmet law will result in a net loss of equal size.

The effect of motorcycle helmet law repeal can also be measured by comparing pre- and post-repeal data on the in-

jury severity of crash-involved motorcyclists. Table 3 presents such a comparison which is based on motorcyclists' OAIS scores. To increase the number of observations in the most serious injury classes (OAIS classes 4, 5, and 6), data for Colorado<sup>7</sup> and South Dakota<sup>6</sup> were aggregated.

The effect of the helmet law repeal is a shift in the injury severity distribution toward a smaller proportion of minor injuries and somewhat larger proportion of life-threatening and fatal injuries,<sup>††</sup> particularly those of injury severity classes 5 and 6. This result is expected if helmets are more effective in reducing severe injuries than in reducing minor injuries, and if helmet use declines in response to the repeal

**TABLE 4—Effect of Helmet Law Repeal on Medical Care and Rehabilitation Expenditures (Based on Experience in Two States) per 100,000 Motorcycles**

	Number of Injured		Difference (3)	Medical Care Cost per Person in 1975 (\$) (4) \$	Medical Care Expenses Averted (5) = (3) × (4) \$
	Pre (1)	Post (2)			
0. No Injury	811.8	826	-14.2	0	0
1. Minor Injury	637.5	480.3	157.2	100	15,720
2. Moderate Injury	484.8	568.5	-83.7	615	-51,475
3. Severe Injury	305.8	316.5	-10.7	1,620	-17,334
4. Serious Injury	167.3	171	-3.7	7,450	-27,565
5. Critical Injury	33.5	68	-34.5	17,345	-598,403
6. Maximum Injury (currently untreatable)	59.8	70	-10.2	1,490*	-15,198
TOTAL	2,500.5	2,500.3	—	1975 (\$) 1979 (\$)	-694,255 -1,110,808
				Gross Annual Cost:	\$1,110,808
				Annual Cost Savings: High	\$466,019
				Low	\$392,638
				Low Annual Net Loss:	\$644,789
				High Annual Net Loss:	\$718,170

SOURCE: see Table 3

\*Includes \$925 (discounted at 7%) saved on postponed funeral expenses.

††This tendency was found in each data set.

of helmet laws. In fact, helmet use in the aggregate sample was 94 per cent in the pre-repeal year and 42.8 per cent in the post-repeal year, representing a decline of 51.2 percentage points.

The effect of helmet law repeal on medical care and rehabilitation expenditures is presented in Table 4. In the standard population, helmet law repeal contributed to an estimated \$694,255 (1975 dollars) of additional expenditures, or \$1,110,808 in 1979 prices. Most of the additional costs are incurred by motorcyclists who sustained critical injuries (OAIS class 5). The additional expenditures are partially offset by a decline in helmet use among motorcyclists. Since helmet use declined by 51.2 per cent in the aggregate sample, it is expected that between \$392,638 and \$466,019 would be saved on helmets, resulting in an annual net loss ranging between \$644,789 and \$718,170 per 100,000 motorcycles. When these figures are extrapolated to all states which repealed their helmet laws, it can be estimated that helmet law repeals annually contribute \$16.1 million to \$18.0 million of additional medical care and rehabilitation expenditures in 1979 prices.

### *Examination of Assumptions*

The cost-benefit analysis presented in Table 2 assumes that the difference in injury severity between helmeted and unhelmeted motorcyclists is due entirely to the effectiveness of helmets. It is conceivable, however, that part or all of the difference is due to confounding factors. For instance, if helmeted motorcyclists travel at lower speeds than non-helmeted motorcyclists, then they would be less likely to sustain injuries as severe as their unprotected counterparts; the evidence is inconclusive on this point.

Data on South Dakota<sup>6</sup> motorcyclists suggest that prior to the accident helmet users were somewhat less likely to exceed the speed limit than were non-users. Among helmet users, 10 per cent exceeded the legal speed limit by six or more miles per hour, while for non-users the figure was 14 per cent. Similar data compiled in the Colorado study<sup>25</sup> indicate that 1.6 per cent of helmet users and 4.1 per cent of non-users exceeded 60 miles per hour before the crash. However, the same study also shows that nearly an equal proportion of motorcyclists in either group traveled more than 45 mph before the accident occurred; 23 per cent among helmet users and 22 per cent among non-users. Similarly, data collected on injured Kansas motorcyclists do not suggest that the estimated pre-crash speed was significantly different between the two groups of motorcyclists.<sup>24</sup>

When the injury severity of helmeted and unhelmeted riders was compared for specific body regions which should not benefit from helmet use (i.e., chest, abdomen, pelvis, and extremities), helmeted motorcyclists were found to have a somewhat lower mean injury severity score than unhelmeted motorcyclists. However, the difference between the mean scores based on the most severe injury sustained was not statistically significant. It appears therefore, that the difference between the two groups of motorcyclists shown in Table 1 reflects helmet effectiveness rather than self-selection. This conclusion is also supported by the finding that

among Oklahoma and South Dakota motorcyclists only 9.9 per cent of the injured helmet users sustained head and facial injuries while 28.5 per cent of the injured non-users received these types of injuries.

Furthermore, the calculations presented in Table 2 assumed that helmet users and non-users had the same probability of being involved in accidents. It is plausible, however, that helmet wearers tend to be a more cautious (safety-minded) group of motorcyclists and are less likely to get involved in accidents. Data from two studies would support this proposition. In Colorado, the estimated crash involvement rate for helmeted motorcyclists was 1.5 per cent, while that for unhelmeted riders was 3.2 per cent. In South Dakota, similar calculations indicate that the crash involvement rates were 1.5 per cent and 2.2 per cent, respectively.

Extending helmet use to a group of motorcyclists at higher risk for accidents will increase the gross benefits due to helmet use and the marginal benefits of law enactment. For instance, if non-users are twice as likely to be involved in crashes as helmet users, and each group is of equal size, then two-thirds of the total gross benefit due to helmet use should be produced by the high risk group. If so, the net benefit due to helmet use and the marginal net benefit estimated on the basis of Table 2 would be too conservative.

On the other hand, the analysis of pre- and post-repeal data (see Table 4) controls for the different crash involvement rates and the different injury severity, because the comparison includes helmet users and non-users at both times. Therefore, it is interesting to note that the estimated annual net loss due to helmet law repeal (\$645,000–\$718,000 per 100,000 motorcycles) is roughly comparable with the estimate using the first method (\$606,000–\$680,000) which is based on Table 2. Moreover, the analyses presented in Tables 2 and 4 were repeated using data on *the most severe injury sustained* (AIS) for Colorado, South Dakota, and Kansas. The estimated gross annual benefit of helmet use was 8.6 per cent lower than that shown in Table 2 while the gross annual cost due to helmet law repeal was 1.2 per cent higher than that reported in Table 4. However, caution is warranted when extrapolating the findings of this study since the accident experience in four states may not be truly representative of the nation.

### *Discussion*

The previous analyses suggest that motorcycle helmet use contributes to society's welfare without considering the value of pain or lives lost. Nevertheless, there are other effects or possible effects that should be considered before setting public policy.

Although the cost of law enforcement activities is unknown, it is not expected to consume a large amount of police resources. Helmet use was over 90 per cent among motorcyclists in states mandating helmet use, suggesting that the cost directly attributable to helmet law enforcement should be very small.

It has been alleged that the use of helmets will increase the rate of neck injuries and interfere with hearing and vision. With regard to neck injuries, a review of the available

evidence<sup>26</sup> and a report by the Department of Transportation<sup>20</sup> (DOT) make it clear that this allegation is unfounded. Since helmets reduce the sound of safety signals and the noise of the motorcycle by a similar degree, the motorcyclist is at no greater disadvantage than the unhelmeted rider to hear safety signals. Although helmet use slightly reduces the field of vision (by 3 per cent), the horizontal field of view exceeds the 210° standard set by federal legislation (FMVSS No. 218).

It is undeniable that discomfort and inconvenience are connected with the use of motorcycle helmets. In a study of Illinois motorcyclists<sup>27</sup>, 45 per cent mentioned discomfort and inconvenience as reasons for *not* wearing helmets, while 5 per cent of the respondents mentioned comfort such as protection from cold air draft as a reason *for* wearing the safety device. Discomfort and inconvenience also influence use of safety equipment by industrial workers, but this does not prevent mandating their use.

It is commonly believed that the constraint of personal freedom is the most important cost borne by motorcyclists. This is a major ethical and legal issue whose ramifications cannot be dealt with in this brief discussion. It is worth pointing out, however, that in the opinion polls that have addressed this issue,<sup>28-30</sup> the majority of all respondents and the majority of motorcyclists interviewed have favored enactment of helmet laws.

Public policy makers may also wish to consider means other than laws to increase the use of motorcycle helmets among motorcyclists. Public information campaigns would eliminate law enforcement costs as well as the restriction of individual freedom felt by some motorcyclists. This assumes that motorcyclists could be persuaded to use the safety device, but similar efforts geared toward encouraging safety belt use have been found to be failures and wasteful of public resources.<sup>31, 32</sup>

Subsidization would shift part or all of the cost of helmets from motorcyclists to the general public by providing federal money to motorcyclists purchasing helmets. This policy removes financial barriers and possibly encourages helmet use among motorcyclists who believe helmets contribute to their safety. However, subsidies would not motivate motorcyclists who perceived themselves as unlikely to have an accident to use helmets; nor would they motivate helmet use among motorcyclists who valued the convenience related to helmet non-use more than the benefits related to helmet use. In a survey of Illinois' motorcyclists,<sup>33</sup> only 21 per cent of the respondents who did not own helmets indicated excessive cost as a reason. Therefore, subsidization of helmet purchase is not expected to increase helmet use significantly among motorcyclists. Moreover, the policy would mainly benefit motorcyclists who otherwise would voluntarily purchase helmets.

Motorcycle helmet users could be charged lower insurance premia than unhelmeted motorcyclists. This policy would provide incentives for unhelmeted motorcyclists to purchase and wear the safety device. However, differential insurance premia would encourage the motorcyclist to claim helmet use in order to reduce his insurance payments when in fact helmets are not used. Without additional administra-

tive controls, this option would invite insurance fraud.

Motorcyclists who fail to wear helmets and sustain head injuries could be denied compensation for injury and damages. It is difficult, however, for courts to determine on a case-by-case basis in which circumstances compensation would be denied, since head injuries are also sustained when helmets are worn. Thus, liability could have financially ruinous consequences for some motorcyclists and appears to be an unduly harsh punishment for injured motorcyclists.

Even though motorcycle helmet laws are not a panacea for reducing injuries and human suffering related to motorcycle use, they seem to be an effective public health policy which increases society's welfare. Repeal of helmet laws or failure to enact them appear to be policies that waste scarce resources and contribute to additional pain and suffering among motorcyclists.

## REFERENCES

1. National Safety Council: Accident Facts, 1977. Chicago, IL: National Safety Council, 1977.
2. U.S. Department of Transportation, NHTSA: Motor Vehicle Safety 1977. Washington, DC: DOT HS-803371, 1978.
3. U.S. Department of Transportation, NHTSA, National Center for Statistical Analysis: Motorcycles: Fatal Accident Reporting Systems. Special Report on Motorcycles. Washington, DC: DOT HS-803186, 1978.
4. Watson GS, Zador PI and Wilks A: The repeal of helmet use laws and increased motorcycle mortality. *Am J Public Health* 70:579-585, 1980.
5. Robertson LS: An instance of effective legal regulation: motorcyclist helmet and daytime headlamp laws. *Law and Society* 10:476-477, 1976.
6. Struckman-Johnson C and Ellingstad VS: Impact of Motorcycle Helmet Law Repeal in South Dakota. Springfield, VA: NTIS, DOT HS-803996, 1979.
7. Dare CE, Owens TC and Krane SW: Impact of Motorcycle Helmet Usage in Colorado: An Executive Summary. Springfield, VA: NTIS, DOT HS-803679, 1979.
8. Dorris AL and Purswell JL: Impact of Motorcycle Helmet Usage in Oklahoma, Vol. I—Research Report. Springfield, VA: NTIS, DOT HS-803681, 1978.
9. Lummis ML and Tucker GL: Impact of the Repeal of the Kansas Motorcycle Helmet Law: An Executive Summary. Springfield, VA: NTIS, DOT HS-803959, 1979.
10. U.S. Department of Health, Education, and Welfare: Motor Vehicle Injury Prevention Program. Washington, DC: Disease Control Program, 1966.
11. Cooper BS and Rice DP: The Economic Cost of Illness Revisited. Washington, DC: Social Security Administration, Office of Research and Statistics, 1975.
12. Acton JP: Measuring the monetary value of lifesaving programs. *Law and Contemporary Problems* 15:46-72, 1976.
13. Motorcycle Industry Council: 1978 Motorcycle Statistical Annual. Washington, DC: 1978.
14. Winn GL: Motorcycle Accident Statistics: Problems and Evaluation. Westerville, OH: American Motorcyclist Association, 1978.
15. Ellingstad VS: Impacts of Motorcycle Helmet Law Repeal in South Dakota—Executive Summary. Springfield, VA: NTIS, DOT HS-803960, 1979.
16. Motorcycle Safety Foundation: Cycle Safety Information: Motorcycle Statistics—1977. Linthicum, MD: Motorcycle Safety Foundation, 1979.
17. American Association for Automotive Medicine: The Abbreviated Injury Scale (AIS). Morton Grove, IL: AAAM, 1976.
18. U.S. Department of Transportation, NHTSA: 1975 Societal Costs of Motor Vehicle Accidents. Washington, DC: Dot, 1976.
19. U.S. Department of Health, Education, and Welfare, PHS, NCHS, NCHSR: Health United States. Washington, DC:

- DHEW Pub. No. (PHS) 78-1232, 1978.
20. U.S. Department of Transportation, NHTSA: The Effect of Motorcycle Helmet Usage on Head Injuries, and the Effect of Usage Laws on Helmet Wearing Rates: A Preliminary Report. Washington, DC: DOT HS-803791, 1979.
  21. Texas Transportation Institute: Evaluation of Motorcycle Safety Helmet Usage Law. College Station, TX: Human Factors Division, Texas A & M University, 1978.
  22. National Center for Statistics and Analysis, NHTSA: Motorcycle Accident Cause Factors and Identification of Counter Measures-Summary Status Report. Washington, DC: DOT HS-501160, 1979.
  23. Ellinger M: Illinois Motorcycle Helmet Usage Study. Illinois Division of Traffic Safety, 1976.
  24. Lummis ML and Tucker GL: Impact of the Repeal of the Kansas Mandatory Motorcycle Helmet Law, Final Report. Springfield, VA: NTIS, DOT HS-804018, 1979.
  25. Dare CE, Owens TC and Krane S: Impact of Motorcycle Helmet Usage in Colorado. Springfield, VA: NTIS, DOT HS-803680, 1978.
  26. Balcerak JC: Moped, minibike and motorcycle accidents. NY State J Med 78:631, 1978.
  27. Hemmerling PM: Knowledge and attitudes as predictors of motorcycle safety helmet usage: A regression analysis. Carbondale, IL: M.S. Thesis, Dept. of Health Education, Southern Illinois University, 1975.
  28. Commonwealth of Pennsylvania: Analysis of the Mandatory Motorcycle Helmet Issue. Harrisburg, PA: Governor's Traffic Safety Council, 1977.
  29. Sund KR: A study of attitude and knowledge as pertains to motorcycle helmets in mandatory and non-mandatory helmet use states. Carbondale, IL: M.S. Thesis, Dept. of Health Education, Southern Illinois University, 1976.
  30. Tatum DK: Nevada's Motorcycle Helmet and Accident Analysis. Carson City, NV: Nevada Office of Traffic Safety, 1978.
  31. Robertson LS, et al: A controlled study of the effect of television messages on safety belt use. Am J Public Health 64:1071-1080, 1974.
  32. Insurance Institute for Highway Safety: Safety Belt Use: A Fact Sheet, Washington, DC: 1978.
  33. Allegrante JP: Explaining safety helmet use by motorcycle operators using a behavioral intention model. Urbana, IL: Ph.D. Thesis, Dept. of Health and Safety Education, University of Illinois, 1979.

### ACKNOWLEDGMENTS

The research on this paper began during the author's post-doctoral fellowship at the Johns Hopkins University, School of Public Health. The careful and considerate guidance of David S. Salkever will not be forgotten. I would also like to acknowledge the help of representatives of the Safety Helmet Council of America, the Motorcycle Safety Foundation, and the Motorcycle Industry Council. However, the responsibility for use and interpretation of the information provided rests with the author.

### Appendix A—Estimation of the Total and Average Number of Helmet Use Years

The total number of years of helmet use can be estimated by multiplication of three factors: (1) the number of motorcycles in use per year; (2) the average number of persons riding a motorcycle (occupancy rate); (3) helmet use observed among motorcyclists. Dividing the product by (4) the number of helmets being replaced annually, yields the average number of years of helmet use.

(1) *Number of Motorcycles in Use:* According to the Motorcycle Industry Council, <sup>13</sup> 7,925,600 motorcycles were operated in 1977. The majority of motorcycles (5,144,129 or 64.9 percent) were registered for use on public highways, while the remainder (2,781,471 or 35.1 percent) were used "off-road." In 1977, 3,133,090 motorcycles were registered in states which either never had helmet laws or had repealed their laws recently. Off-road motorcycles are excluded from such regulation.

(2) *Average Occupancy Rate of On-Road and Off-Road*

*Motorcycles:* Roadside surveys reported average occupancy rates ranging between 1.22 and 1.27 persons per motorcycle.<sup>6-8</sup> Although the occupancy rate of off-road motorcycles is unknown, the design of such motorcycles would suggest that only one person will use the motorcycle. Thus, the average occupancy of on-road and off-road motorcycles, is assumed to be 1.25 and 1, respectively.

(3) *Helmet Use:* Helmet use is substantially different in states with and without helmet laws. Voluntary helmet use is assumed to range between 40 percent and 50 percent, while helmet use in states with helmet laws is expected to range between 90 percent and 100 percent.

(4) *Annual Replacement of Helmets:* Currently, about 1.2 million motorcycles helmets are sold annually.<sup>†††</sup>

Using the previous data, the total and average number of years of helmet use can be estimated (see Table A-1).

<sup>†††</sup> Personal communication May 10, 1979 with Ivan Wagar, President of Safety Helmet Council of America.

TABLE A-1—Calculation of Total and Average Number of Helmet Use Years

Motorcycle Status	No. of Motorcycles in Use (1977)	Average Occupancy Rate	Per Cent Helmet Use	Helmet Use Years Helmet Use	
				High	Low
On-road	5,144,129		—	—	—
States with law	2,011,039	1.25	90-100	2,513,799	2,262,419
States without law*	3,133,090	1.25	40-50	1,958,181	1,566,545
Off-road	2,781,471	1.0	40-50	1,390,736	1,112,588
TOTAL	7,925,600		Total helmet use years:	5,862,716	4,941,552
			Annual replacement:	1,200,000	1,200,000
			Average # of use years:	4.89	4.12

\*Alaska, Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Minnesota, Montana, Nebraska, New Hampshire, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Dakota, Texas, Utah, Washington, and Wisconsin.